LA-UR-03-4319

A PHYSICS-BASED METRIC FOR STUDYING SECONDARY INSTABILITIES IN SHOCK-ACCELERATED FLUID SYSTEMS

Michael Cannon[1], Christopher Tomkins[2], William Rider[1], James Kamm[1],
Mark Marr-Lyon[2], Peter Vorobieff[3], Robert Benjamin[2]

[1]Los Alamos National Laboratory, CCS Division
[2]Los Alamos National Laboratory, DX Division
[3]University of New Mexico, Department of Mechanical Engineering

A continuing challenge in computational fluid dynamics is the accurate numerical prediction of the onset and growth of secondary instabilities and a meaningful characterization of the role they play in the transition to turbulence. A recent diagnostic advance applied to an ongoing experimental study of the evolution of shock-accelerated, heavy-gas cylinders has led to time-resolved concentration-field data with high enough spatial resolution to visualize developing secondary instabilities in detail. This data has allowed us to develop a reliable physics-based metric that is used to characterize the temporal evolution of the instabilities and to compare them with the results of numerical simulations.

Our metric measures two features of the gas-air interface – the characteristic waviness associated with the Kelvin-Helmholtz instability together with the large spatial gradient in gas density. (These are also the features used by the human visual system to detect the instabilities.) The high signal-to-noise ratio of the new experimental data allows us to use a derivative to measure the gradient, and a morphological operator is used to convert the derivative into a mask whose edge accurately follows the gas-air interface. The Fourier transform is used to measure the waviness of this edge. This Fourier measure of the secondary instability permits ensemble averaging over many instances of an experiment, thus allowing meaningful statistics to be gathered.

The metric is applied *in an absolutely identical manner* to both the simulated results and experimental data and quantitatively extracts the features of interest. It produces results helpful in understanding the physics of the phenomenon and provides a unique tool for code validation. Measurements of the temporal evolution of the secondary instabilities and comparisons to simulated results will be presented.